DRAFT

Anaconda Regional Water and Waste Operable Unit
Anaconda Smelter NPL Site

Anaconda Granulated Slag Pile
Position Paper Supporting a No-Action Record of Decision

ARCO

Atlantic Richfield Company
307 East Park, Suite 400
Anaconda, MT 59711

August 26, 1994

DRAFT

TABLE OF CONTENTS

DRAFT

LIST OF TABLES

LIST OF FIGURES

DRAFT

ANACONDA GRANULATED SLAG PILE
POSITION PAPER SUPPORTING A NO-ACTION RECORD OF DECISION

1.0 INTRODUCTION

This paper has been prepared by the Atlantic Richfield Company (ARCO). The paper provides a synthesis of the available data characterizing the Anaconda Granulated Slag Pile (AGSP), located in Anaconda, Montana, and its potential human health and environmental impacts.

1.1 SITE NAME

The site name is as follows:

Anaconda Granulated Slag Pile of the Anaconda Regional Water and Waste Operable Unit. The Anaconda Regional Water and Waste Operable Unit is located in the Anaconda Smelter National Priorities List (NPL) Site.

1.2 LOCATION

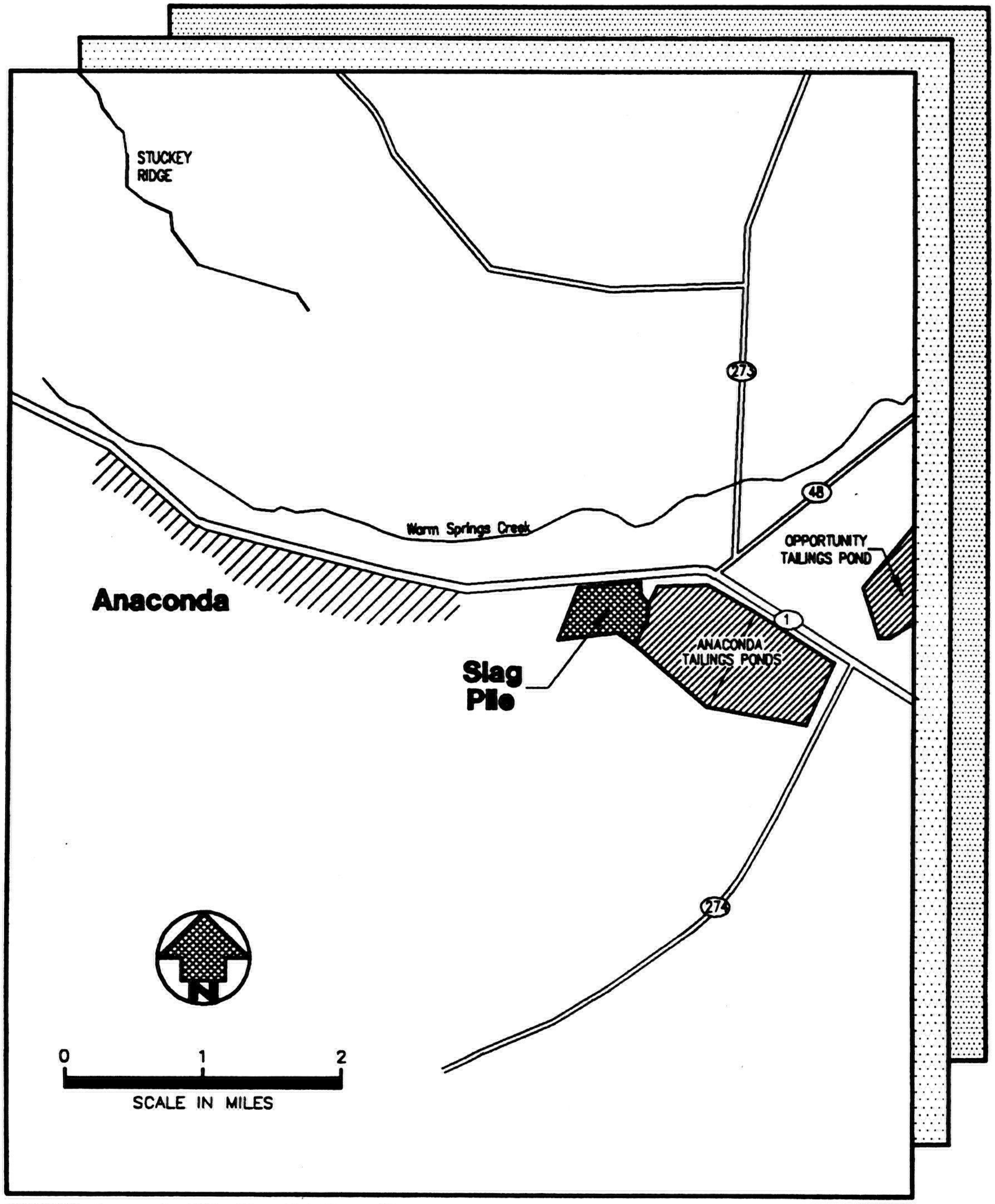
The slag pile comprises a 130-acre area located approximately one mile east of the town of Anaconda in Deer Lodge County, Montana (Figure 1). The AGSP is situated on the western edge of the Deer Lodge valley. The population centers of Anaconda, Opportunity, Warm Springs, and Deer Lodge are located within 30 miles of the AGSP.

1.3 STATEMENT OF BASIS AND PURPOSE

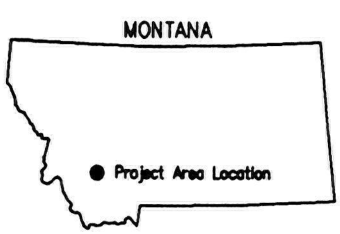
The U.S. Environmental Protection Agency (EPA, 1991) provides the following criteria for establishing the applicability of a no-action Record of Decision (ROD):

- when the site or a specific problem or area of the site (i.e., an operable unit) poses no current or potential threat to human health or the environment;
- when the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) does not provide the authority to take remedial action; or
- when a previous response eliminated the need for further remedial response.

8/94 D:\2350\2350-1.DWG



SOURCE: Anaconda NPL Site, Old Works/East Anaconda Development Area Operable Unit Remedial Investigation and Feasibility Study. PTI Environmental Services, Bellevue, WA. June 1992.



LOCATION OF THE ANACONDA GRANULATED SLAG PILE

PROJECT: 2350	DATE: AUGUST, 1994
REV:	BY: MEG CHECKED:

Figure 1

DRAFT

The purpose of this position paper is to demonstrate that a no-action ROD is appropriate for the AGSP based on a lack of current or potential threat to human health and the environment. The proposed remedy is consistent with CERCLA, the Superfund Amendment Reauthorization Act (SARA), and the National Contingency Plan (NCP). The scope of the arguments presented herein is delineated by the body of existing physical and chemical data characterizing the AGSP and interpretation of those data. Physical and chemical data were obtained from the Anaconda Smelter Remedial Investigation/Feasibility Study (RI/FS) Granulated Slag Pile, Draft Stage 1 Remedial Investigation (RI) Report (Tetra Tech, 1985) and from information to be included in the forthcoming Anaconda Regional Water and Waste Operable Unit RI Report and developed under the Anaconda Smelter RI/FS Consent Order.

1.4 DESCRIPTION OF PROPOSED REMEDY

No action is necessary for the AGSP due to a lack of current or potential threat to human health or the environment. The lack of such threat is demonstrated by information presented herein.

2.0 NATURE, EXTENT, AND TRANSPORT OF ANACONDA SMELTER SLAG

This section describes nature, extent, and transport characteristics of slag from the AGSP. Also included are discussions of the AGSP's history, its limited human health and environmental impacts, and the local community's participation in related regulatory affairs. The limited nature of the AGSP's human health and environmental impacts is based on observations made and data collected during the previously referenced RI/FS studies as well as the results of leaching tests, and other risk analysis information.

2.1 SITE NAME, LOCATION, AND DESCRIPTION

The AGSP is a 130-acre granulated slag pile located in the Anaconda Regional Water and Waste Operable Unit of western Montana's Anaconda Smelter NPL Site (Figure 1). The slag pile is situated just south of State Highway 1 and north of the Anaconda Smelter stack location. The AGSP and immediately adjacent lands are currently owned by ARCO and physical access to the slag pile and adjacent Smelter Hill area is limited by fencing and access restrictions, as enforced by routine security patrols. Land uses in areas adjoining the AGSP are currently zoned industrial/commercial and recreational. The AGSP is located within an area designated as a waste management unit. Remaining lands adjacent to the AGSP are semi-arid foothills forming part of the Warm Springs Creek watershed.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

From 1884 to 1902, smelting operations occurred in the Upper and Lower Works areas of the adjacent Old Works/East Anaconda Development Area Operable Unit, just north of the AGSP. The present Anaconda Smelter site, originally known as the Washoe Works and later as the Anaconda Reduction Works, was developed southeast of the Lower Works in 1902. The Anaconda Smelter operated from 1902 to 1980, producing the slag contained in the AGSP.

The Anaconda Smelter Site was placed on the NPL on September 8, 1983 (48 Federal Register 40658). The U.S. Environmental Protection Agency (EPA) divided the site into several operable units due to its size and complexity. As noted above, the AGSP is included in the Anaconda Regional Water and Waste Operable Unit.

The initial Superfund investigations for the Anaconda Smelter NPL Site as a whole began in 1984. These studies were completed in 1985 and are summarized in the Anaconda Smelter RI/FS Master Investigation Draft RI Report (Tetra Tech, 1987). As part of the initial studies, a focused investigation of the AGSP was conducted. The objectives of the focused investigation were to (Tetra Tech, 1984):

- describe the physical characteristics of the slag and assess the ability of wind and surface runoff to move slag from the pile;
- provide estimates of the area, volume, and mass of the slag pile;
- describe the chemical composition of the slag; and
- evaluate whether trace elements are readily leached from the slag and identify which elements may be most mobile.

The findings of this focused investigation provide the basis for many of the conclusions presented herein. Also, investigative activities conducted in connection with the Anaconda Regional Water and Waste Operable Unit RI, a portion of which addresses the AGSP, are currently underway. Information collected for this study is included in this position paper, as appropriate.

EPA issued a ROD for the Old Works/East Anaconda Development Area Operable Unit located immediately north and west of the AGSP. The ROD describes EPA's selected remedy, with supporting rationale, for the Old Works/East Anaconda Development Area. The ROD includes the use of Anaconda Revegetation Treatability Study (ARTS) methods and engineered covers to reduce surficial soil arsenic concentrations to the recreational and future commercial/industrial action level of 1,000 parts per million (ppm, or milligrams per kilogram) and to the current commercial/industrial action level of 500 ppm. Human health risk assessments made for the Old Works/East Anaconda Development Area Operable Unit focused on the ingestion and inhalation of arsenic, cadmium, copper, lead, and zinc (Life Systems, 1993). Therefore, discussions presented later in this document include these pathways and elements.

An institutional controls program for the Anaconda Smelter NPL Site has been adopted by Anaconda-Deer Lodge County. Institutional controls, such as deed restrictions and zoning ordinances, serve to restrict access, restrict future land use and groundwater use, and prevent or limit exposure to particular areas. There presently are several institutional controls in place at the AGSP.

DRAFT

First, Anaconda-Deer Lodge County has instituted a Development Permit System (DPS) which controls land use and development in the county. The AGSP is within the area covered by the DPS and, more specifically, the area of the DPS designated as the Superfund Planning Area Overlay District (SPAOD). Among other things, the SPAOD assures that future land use will be compatible with the presence of contaminants and remedial actions, and protects and provides for the preservation and maintenance of remedial actions. Any applicant who intends to undertake certain development activities must obtain a permit through the DPS. The DPS imposes limitations on the type of uses by subarea and provides for an application process that assures the remedy at each subarea will be protected or replaced, or if a change in use is proposed, that an appropriate remedy is implemented by the developer. Under the DPS, a permit is required for any development or change in use. The permit application allows the County to evaluate and insure that actions appropriate to the situation will occur as part of the development. Development in flood plains and drilling of new potable water wells are both subject to a permit and controls to insure present conditions are not exacerbated. The 1994 amendments have been reviewed and comments incorporated by the Anaconda-Deer Lodge planning department staff. The formal amendment process is underway at present time.

Second, since ARCO owns the property, it can control present land use such that the AGSP is not subject to recreational, industrial, or residential use. Additionally, ARCO can control future land use if it conveys the property through deed restrictions, restrictive covenants, or conservation easement.

Finally, ARCO performs routine security inspections 24 hours per day in this area so that individuals are not allowed access to the AGSP. As a further precaution, fences have been placed around the entire slag pile. The existing public and private institutional controls assure that use of the AGSP property will remain as it is currently: a slag pile. Access will continue to be restricted. No public access or on-site use of the slag is permitted. There will be limited use of the slag in the traps at the new Old Works golf course.

A no-action ROD for the AGSP is consistent with EPA's selected remedies for other portions of the Anaconda Smelter NPL Site. For example, the use of slag in traps at the Old Works golf course is included in EPA's selected remedy for the Old Works/East Anaconda Development Area. Furthermore, the AGSP is a primary copper smelter slag which is exempt from Resource Conservation and Recovery Act (RCRA) regulation as a hazardous waste. 40 CFR Section 261.4(b)(7) provides that solid waste from the extraction, beneficiation, and processing of ores and minerals, listing specifically slag from primary copper processing, are not hazardous wastes. EPA reached this conclusion after extensive study, public comment, and rulemakings. By virtue of this regulation, EPA has made the determination that primary copper smelter slag does not pose a present or potential hazard to human health or the environment.

2.3 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The total population of Deer Lodge County is approximately 10,350, with approximately 6,750 (65 percent) of these individuals residing in the town of Anaconda, 1.5 miles west of the AGSP (1990 census data; Deer Lodge County Planning Department, personal communication, September, 1993). The remaining inhabitants of Deer Lodge County reside in the communities of Warm Springs or Opportunity, located six miles northeast and six miles east of the AGSP, respectively, or in scattered rural areas. The community of Deer Lodge is located about 30 miles north of the AGSP in Powell County. The population of Deer Lodge is approximately 3,380 (1990 census data, Powell County Clerk, personal communication, September, 1993).

There have been several evaluations by the public and local officials of the land use in the SPAOD over the last four years. SPAOD is the planning area of the community that includes the AGSP. The following plans, regulations, and studies were conducted by representatives of and consultants to Anaconda-Deer Lodge County for the SPAOD with numerous public presentations and opportunities at formal public hearings before the Anaconda-Deer Lodge County Planning Board and Commissioners for citizen review and input.

- Anaconda-Deer Lodge County Master Plan, 1990
- Anaconda-Deer Lodge County Comprehensive Master Plan Amendments, 1992
- Anaconda-Deer Lodge County Development Permit System, 1992
- East Anaconda Development Area Urban Design Plan, 1992
- Regional Historic Preservation Plan (RHPP), 1993

In each of the above efforts, the AGSP was identified as an area that would continue in its current status as a slag pile. No other use was proposed at any of the meetings. In the RHPP, it was specifically identified as a historical/cultural resource with an "observable" performance role with no access or participatory function.

DRAFT

2.4 SITE CHARACTERISTICS

The AGSP is situated at an elevation of approximately 5,400 feet above sea level. Local climatic conditions are characterized as a semi-arid continental type with cold winters, cool summers, and low precipitation. Between 1906 and 1985, average annual temperatures ranged from approximately 40°F to 46°F, with a mean of approximately 42°F. The average annual precipitation measured at the East Anaconda weather station for the period 1951 through 1974 was 13.7 inches, while total annual precipitation for this period of record ranged from approximately 7 to 22 inches. The average evaporation occurring between April and November at the East Anaconda weather station (measured between 1974 and 1978) was 48.9 inches. Wind speed data were collected at the nearby Anaconda Smelter Site, where the predominant wind direction is from west to east. The average monthly wind velocity ranged from 13.5 mph in July to 23.0 mph in December and the maximum monthly wind velocity ranged from 51.3 mph in August to 65.0 mph in January (period of record: 1906 to 1945). More recent meteorological data, collected at the Teressa Ann Terrace meteorological station located southwest of the Old Works/East Anaconda Development Area Operable Unit, indicate average monthly temperatures from August 1989 to March 1991 ranging from 20.5°F in December to 64.0°F in July. The high and low temperatures recorded during this period were 92°F and -25°F, respectively. Precipitation data collected at the Old Works/East Anaconda Development Area Operable Unit and three other stations located in the southern Deer Lodge Valley indicate that the areal arithmetic mean annual rainfall for 1991 was 10.1 inches. Within the Old Works/East Anaconda Development Area Operable Unit, the maximum monthly total precipitation was 2.3 inches recorded in June. The lowest monthly total was 0.05 inches recorded in October (ARCO, 1992; PTI, 1993).

The drainage ways nearest the AGSP, to which any runoff would flow, are the Smelter Hill drainage system and the south drainage ditch from Anaconda, which flows along the north side of the AGSP between it and State Highway 1. Both the Smelter Hill drainage system and the south drainage ditch flow into the Opportunity tailings pond system.

Data collected from nearby monitoring wells indicate that groundwater is present at depths from approximately 24 to 75 feet below the base of the AGSP. This groundwater is unconfined (Konizeski, et al., 1968). The groundwater flow direction in the vicinity of the AGSP is generally from west to east [Robert Galyen, Environmental Sciences and Engineering Inc. (ESE), Butte, MT, personal communication, August 4, 1994], down-valley toward Silver Bow Creek.

DRAFT

Vegetation in the vicinity of the AGSP includes rye grasses and small shrubs. The surrounding foothills provide cover and habitat for mammals, birds, and insects.

2.4.1 Origin of Anaconda Smelter Slag

As previously discussed, the Anaconda Smelter processed copper ore from mines in the Butte, Montana area from 1902 to 1980. Primary minerals in the ore rock included chalcocite (copper sulfide), bornite (copper-iron sulfide), and enargite (copper-arsenic sulfide). The ore rock also contained lesser amounts of minerals bearing zinc, cadmium, lead, and silver. This ore was mechanically concentrated, roasted, and then smelted in reverberatory furnaces. Products of these operations included copper matte (an intermediate product containing sulfur and other impurities) and slag. As part of the smelting operation, the molten slag was continuously quenched in a water stream. This quick cooling caused the molten slag to vitrify into small, relatively uniform particles with a glassy texture. The granulation is not the result of a crushing or grinding operation. The quench-water/slag slurry was directed via flumes to the AGSP for disposal.

2.4.2 Physical Characteristics of Anaconda Smelter Slag

The AGSP covers an area of approximately 130 acres, has an estimated volume of about 16 million cubic yards, and an approximate mass of 26.5 million tons[1]. The slag pile has an average thickness of about 76 feet, although this thickness varies significantly with location on the pile. Material in the AGSP consists of black, granular slag produced by the process described above. Ten discrete slag samples were collected during the Anaconda Smelter RI/FS for physical and chemical characterization. Sieve analyses conducted on these samples indicate that approximately 90 percent of the slag particles may be characterized as medium to very coarse sand (0.25 to 2.0 millimeters in diameter) or larger. Photomicrograph analyses indicate that the slag particles are not porous, but are solid, amorphous particles with a vitreous (glassy) luster.

---

1 Based on an average bulk density of 122.3 pounds per cubic foot (1.96 grams per cubic centimeter), as established in the laboratory. The density of the slag particles was calculated to be 2.92 grams per cubic centimeter, based on the average bulk density and a pore volume ratio of 0.168 cubic centimeters per gram of slag.

DRAFT

2.4.3 Chemical Characteristics of Anaconda Smelter Slag

The slag is composed mostly of iron silicate. Small quantities of residual, non-ferrous metals remain in this matrix because the smelting operation was not 100 percent efficient. These metals are chemically fixed in the glassy, iron silicate matrix causing the slag to be inert. Slag samples collected from the AGSP during the Anaconda Smelter RI/FS were analyzed for a variety of metals, metalloids, sulfur forms, and pH. The results of the chemical analyses are provided in Table 1. These results indicate that the most abundant metals in the slag are iron, zinc, and aluminum [mean concentrations of 307,500 milligrams per kilogram (mg/Kg), 26,198 mg/Kg, and 21,690 mg/Kg, respectively]. Slag samples also were analyzed for the Anaconda Regional Water and Waste Operable Unit RI (Robert Galyen, personal communication, August 1, 1994). These data, which are included on Table 1, are consistent with the reported mean values from the Anaconda Smelter RI/FS.

2.4.3.1 Leaching Characteristics of Anaconda Smelter Slag

Leachability is the degree to which chemical constituents are released from a solid material in contact with a liquid, as characterized by concentration changes in the contacting liquid (leaching solution). Leachate column tests were conducted for the Anaconda Smelter RI/FS to assess the degree to which metals and metalloids may be released from samples of granulated slag collected from the AGSP. The tests were conducted in the laboratory by packing two columns with slag material and allowing the leaching solution to flow through the columns. The initial (pre-test) pH of the leaching solution used in the tests ranged from about 4.2 to 4.4 pH units; thus, the leaching tests did not simulate actual field conditions where slag particles would come into contact with less acidic rain water and snowmelt. Leachate samples were collected for subsequent chemical analyses. The samples typically were collected after one or more "pore volumes"[2] of leachate had issued from the column. The tests were conducted for up to 25 pore volumes. The total elapsed times for 25 pore volumes to pass through the columns were 232 and 239 minutes.

The results of the leaching tests are summarized on Table 2. The results of the tests show that slag samples from the AGSP are capable of buffering acidic solutions, as indicated by rapid pH increases in the leaching solution. As shown on Table 2, the pH in the leaching solution increased from acidic (pH of approximately 4.2 and 4.4) to slightly basic (pH of 7.6 and 7.2) after only one pore volume of

---

2 A pore volume is equivalent to the calculated pore space in the slag sample occupying the column apparatus.

DRAFT

Table 1

SLAG CHEMICAL CHARACTERISTICS (Tetra Tech, 1985)

Parameter	Range	Mean[a]	Standard Deviation	Coefficient of Variation[a]
Acid Extractable Metals (mg/kg dry weight basis)				
Aluminum	17,100 - 30,700	21,690	3,836	17.0
Antimony	42 - 219	111	53	47.7
Arsenic	498 - 3,190	1,978	800	40.4
Barium	266 - 3,190	1,180	846	71.7
Beryllium[b]	<2.5 - 2.7	2.5	0.06	2.4
Boron	<8.0 - 170	33	48.5	147
Cadmium	4.4 - 44	22.8	10.9	47.8
Chromium	45 - 436	271	125	46.1
Cobalt	28 - 517	142	147	103.5
Copper	3,140 - 9,760	6,271	1,831	29.2
Iron	188,000 - 341,000	307,500	45,078	14.7
Lead	364 - 4,310	2,044	1,413	69.1
Manganese	710 - 17,200	3,373	5,376	159.4
Mercury[b]	<0.04 - 0.08	0.04	0.013	32.5
Molybdenum	<3 - 670	151	231	153.0
Nickel	<20 - 291	71	84	118.3
Selenium[b]	<50 - 85	54	11	20.4
Silver	<5.0 - 88	16	26	162.5
Tin	<20 - 220	101	66	65.3

a The detection limit was used for values reported as less than the detection limit.

b Nine of the ten values reported are less than the detection limit

Table 1

(continued)

SLAG CHEMICAL CHARACTERISTICS (Tetra Tech, 1985)

Parameter	Range	Mean	Standard Deviation[a]	Coefficient of Variation[a]
Acid Extractable Metals (mg/kg dry weight basis)				
Vanadium	83 - 229	156	52	33.1
Zinc	8,380 - 36,300	26,198	8,330	31.8
Total Sulfur (%S, dry weight basis)	0.51 - 1.36	1.10	0.26	23.6
Pyritic sulfur (%S, dry weight basis)[c]	<0.01	<0.01	0.0	0.0
pH (1:1 slurry)	6.4 - 8.9	--	--	--

c All ten values were reported as <0.01.

SLAG CHEMICAL CHARACTERISTICS (ESE, 1994)[d]

Parameter	Reported Concentration (mg/Kg)
Arsenic	2,690
Cadmium	23.3
Copper	5,550
Lead	2,730
Zinc	23,300

d Robert Galyen, personal communication, August 1, 1994.

DRAFT

Table 2

SLAG LEACH COLUMN TEST RESULTS

Column (a)	Pore Volume	pH	Arsenic (μg/L)	Cadmium (μg/L)	Copper (μg/L)	Iron (μg/L)	Lead (μg/L)	Zinc (μg/L)
1	Blank	4.2	<3.6	<4.0	722	34	5.6	236
	1	7.6	3.8	<4.0	128	<7.8	<3.0	326
	2	7.1	<3.6	18	633	<7.8	<3.0	1,680
	5	6.6	<3.6	25	5,450	<7.8	7.2	1,260
	10	6.4	<3.6	19	10,800	<7.8	10	877
	15	6.4	<3.6	18	10,900	<7.8	13	768
	20	6.3	<3.6	16	11,000	<7.8	19	699
	25	6.3	<3.6	<4.0	9,460	11	25	565
2	Blank	4.4	<3.6	<4.0	320	21	3.7	17
	1	7.2	3.8	<4.0	285	<7.8	3.2	726
	2	6.6	<3.6	30	1,970	<7.8	3.4	2,710
	5	6.7	3.9	28	8,500	<7.8	7.5	1,200
	10	6.6	4.7	18	11,000	<7.8	9.2	784
	15	6.4	<3.6	18	11,600	<7.8	11	688
	20	6.3	5.5	<4.0	10,500	12	16	633
	25	6.4	<3.6	<4.0	10,100	34	21	579

[a] Data from the Anaconda Smelter RI/FS (Tetra Tech, 1985)..

leaching solution had issued from the test columns. The test results indicate that initially acidic solutions may leach minor amounts of copper from the slag and that other constituents (arsenic, cadmium, iron, lead, and zinc) are less readily leached from the slag.

The column tests conducted for the Anaconda Smelter RI/FS are broadly similar to Toxicity Characteristic Leaching Procedure (TCLP) tests because both types of tests involve leaching of material with a moderately acidic solution and subsequent analysis of the leachate. Maximum leachate concentration data from the column tests, as presented on Table 2, and corresponding TCLP criteria[3] are summarized below.

Column	Arsenic (μg/L)	Cadmium (μg/L)	Lead (μg/L)
1	3.8	25	25
2	5.5	30	21
TCLP Criteria	5,000	1,000	5,000

A TCLP test[4] also was conducted on a sample of the granulated slag. The results of this test are summarized below.

Analyte	TCLP Test Result (μg/L)	TCLP Criteria (μg/L)
Arsenic	< 10.0	5,000
Barium	1,480	100,000
Cadmium	< 10.0	1,000
Chromium	< 10.0	5,000
Lead	< 100	5,000
Mercury	< 0.100	200
Selenium	70.0	1,000
Silver	40.0	5,000

3 40 CFR Part 261.24 (a) amended at 58 FR 46040, August 31, 1993.

4 40 CFR Part 261, Appendix II, Method 1311.

As shown, measured concentrations of metals and metalloids generated during the TCLP test are orders of magnitude lower than the TCLP regulatory levels. This comparison indicates that the slag does not exhibit the characteristic of toxicity.

The column and TCLP test results provide very conservative estimates of the leaching potential of slag from the AGSP relative to field conditions. Evaluation of the test results indicates that, even under a rigorous laboratory setting with aggressive, acidic leaching solutions, the slag does not readily liberate metals or metalloids. This finding is consistent with the chemically inert nature of the slag due to the incorporation of the metals and metalloids in the slag's vitrified iron silicate matrix. As previously noted, the slag particles are not the product of a crushing or grinding operation; therefore; the particles are considered to be fully vitrified. It is noteworthy that EPA recommends vitrification as a demonstrated method for reducing the mobility of contaminants from hazardous soils[5,6]. Much lower metal concentrations would be expected under field conditions than in the TCLP or leachate column tests due to differences in the initial (pre-test) pH of the leaching solution. In general, the solubility of metals increases as the leaching solution becomes more acidic. As noted above, the initial pH of the leaching solution in the leachate column tests ranged from 4.2 to 4.4. Under field conditions, however, less acidic rain water and snowmelt would constitute the leaching solution.

2.4.4 Evaluation of Potential Transport Pathways and Exposure Routes

Potential pathways by which metals and metalloids could be released from the AGSP and by which humans may be exposed are as follows:

- mobilization and transport by wind;
- mobilization and transport in surface-water runoff following precipitation and snowmelt events;

---

5 See RCRA Land Disposal Restrictions, 40 CFR Part 268, and in particular, 40 CFR Part 268.45, Treatment Standards for Hazardous Debris.

6 Superfund Innovative Technology Evaluation (SITE) Program, Technology Profiles, Fifth Edition, November, 1992. See pp. 138-139 regarding Plasma Arc Vitrification: *"The technology can process organic and inorganic wastes. It is most appropriate for mixed waste, transuranic waste, chemical plant waste,* ***soil containing*** *both* ***heavy metals*** *and organics, incinerator ash, munitions, sludge, and hospital waste"* (emphasis added).

- leaching by infiltrating waters with subsequent transport to the underlying groundwater system; and

- direct contact (inhalation; adherence to skin with subsequent ingestion during hand-to-mouth behavior).

These potential pathways and exposure routes are examined in detail in the following sections. The discussions are based on recent observations, information collected during the Anaconda Smelter RI/FS and the Anaconda Regional Water and Waste Operable Unit RI, and assessments of human exposure to arsenic and lead in primary copper smelter slag.

2.4.4.1 Wind Transport

As described above, particle sizes of materials comprising the AGSP are in the coarse to very coarse sand range. Particles of this size, and with the relatively high density of slag[7], are generally not prone to mobilization by winds of the velocities typically encountered in the vicinity of the AGSP, as supported by field observations (see Section 2.4). Little evidence of slag has been noted in the area east and northeast (downwind) of the AGSP in the margin between the slag pile and State Highway 1, even during prolonged periods of snow on the ground when the black slag particles should be most evident.

In combination, the available data indicate that airborne transport of metals and metalloids from the AGSP is negligible. This is supported by air monitoring data gathered to characterize the nearby Old Works/East Anaconda Development Area Operable Unit. These data were collected both upwind and downwind of the AGSP. EPA's 1994 ROD for the Old Works/East Anaconda Development Area indicates that air monitoring data collected over a three year period found no exceedances of federal or state ambient air quality standards, indicating that air quality is not adversely affected by the waste materials or soils present at the site. Air quality data collected for the Old Works/East Anaconda Development Area also characterize potential dust emissions from the AGSP due to the proximity of the two areas.

7 As previously noted (Section 2.4.2), the particle density of the slag is calculated to be 2.92 grams per cubic centimeter. This density is significantly larger than that of typical sand, which would have a density similar to that of silica (2.65 grams per cubic centimeter).

2.4.4.2 Surface-Water Transport

Very little surface runoff has been observed from the AGSP. Field observations made during the Anaconda Smelter RI, and those made subsequently, indicate no sign of erosion, surface runoff channels, or slag redistribution due to the presence of water or water movement. This is likely due to the arid local conditions and the relatively large and uniform particle size of the slag material. As noted in Section 2.4, the average annual precipitation in the vicinity of the AGSP ranges from approximately 10 to 14 inches whereas the average annual pan evaporation is approximately 49 inches, indicating a net moisture loss in the area. These dry conditions indicate that the volume of water available for runoff from the AGSP is small. Evaporation from the AGSP is further enhanced by its dark color, which promotes the retention of heat from solar radiation.

The large and uniform particle distribution of the slag suggests that any precipitation remaining on the AGSP would be more prone to absorption within pore spaces of the slag pile than to runoff. Calculations made during the Anaconda Smelter RI/FS indicate that the slag materials may have a hydraulic conductivity of about 0.02 to 0.09 centimeters per second whereas the 100-year, 1-hour rainfall event is estimated to be 0.65 inches per hour (approximately 10^{-4} centimeters per second). These calculations indicate that pore spaces within the AGSP could theoretically absorb, via infiltration, all waters associated with an intense local storm event, thereby greatly limiting runoff potential.

The available data indicate that the AGSP does not impact adjacent surface waters. Significant volumes of runoff do not originate on the AGSP due to high evaporation rates and the tendency for any rain water or snowmelt to be absorbed within pore spaces of the pile. Because runoff from the AGSP is small, if not negligible, any constituents of concern mobilized by runoff to the Smelter Hill drainage system and the south drainage ditch from Anaconda would also be small, if not negligible. As previously noted, the Smelter Hill drainage system and the south drainage ditch from Anaconda both drain to the Opportunity Tailings Pond rather than to local streams such as Mill Creek or Warm Springs Creek.

2.4.4.3 Transport to the Groundwater System (Leaching)

The potential mechanism by which metals and metalloids originating in the slag could be transported to the groundwater system would be leaching within the slag pile by through-flowing rain water/snowmelt and percolation of the leachate through underlying soils to the water table. This mechanism is largely controlled by the volume of any water passing through the slag and underlying vadose zone and the leachability of metals and metalloids in the slag when exposed to rain water and snowmelt. As demonstrated below, this transport mechanism is not effective at the AGSP

As described in the previous section, incident rain water and snowmelt either evaporates or is absorbed by pore spaces within the AGSP rather than concentrating as surface runoff. The volume of rain water and snowmelt available for absorption by the AGSP is greatly limited by the net evaporation in the Anaconda area (i.e., annual precipitation < < annual evaporation), as enhanced on the AGSP by the heat retention characteristics of the dark slag material. Due to the dry climate of the Anaconda area, a moisture deficiency is probably present throughout much of the AGSP and underlying soils. Under such conditions, rain water and snowmelt that does not evaporate from the slag surface would fill the soil-moisture deficiency within the slag pile and likely would not pass through the slag and vadose zone to the water table (total thickness of about 100 to 150 feet of moisture-deficient, unsaturated materials).

The results of the leachate column tests conducted for the Anaconda Smelter RI/FS and a TCLP test conducted on a sample of the granulated slag indicate that the metals and metalloids in the slag are not readily available for leaching due to their incorporation in a vitrified, iron silicate matrix. The leachate column tests were conducted using an acidic leaching solution with a pH of approximately 4.2 to 4.4 pH units. As noted above, the solubility of most metals typically increases with decreasing pH. Therefore, the leaching potential of the metals and metalloids in the slag when exposed to near-neutral pH rain water and snowmelt should be even lower than the leaching potential characterized during the column tests. Also, metals/metalloids in the AGSP that may be mobilized by leaching, if any, may be reduced in concentration by natural attenuation mechanisms in the moisture-deficient soils of the vadose zone.

The available data indicate that the AGSP does not impact the underlying groundwater system because 1) rain water and snowmelt on the AGSP do not percolate downward to the water table due to high evaporation losses and soil-moisture deficiencies, and 2) metals and metalloids in the slag are not readily leached by rainwater or snowmelt. The expected negligible impact of the AGSP on local groundwater is supported by analytical data characterizing groundwater samples collected from nearby monitoring wells. The Anaconda Granulated Slag Pile Draft Stage I RI Report (Tetra Tech, 1985) indicates that groundwater from a monitoring well located upgradient of the AGSP (well no. 98) contains higher concentrations of several metals and metalloids than monitoring wells located downgradient of the

AGSP (well nos. 21, 35, and 36). This observation is supported by more recent groundwater chemistry data collected during the Anaconda Regional Water and Waste Operable Unit RI. Chemical data for groundwater samples collected from wells in the vicinity of the AGSP are presented on Table 3; well locations are shown on Figure 2. The groundwater flow direction reportedly is from west to east (Robert Galyen, personal communication, August 4, 1994). Therefore, wells located to the west of the AGSP characterize upgradient conditions and wells located east of the AGSP characterize downgradient conditions. Monitoring wells MW210 and MW227 were selected to characterize upgradient conditions and well MW211 was selected to characterize downgradient conditions. These wells were chosen for this analysis because they are located such that other potential metal/metalloid sources in the area (e.g., the Anaconda tailings pond) should not significantly influence the results of sample analyses and also because available sample results for these wells are from the same general time frame (early 1992 through mid-1993). For ease of comparison, ranges of analytical data characterizing groundwater quality upgradient (wells MW210 and MW227) and downgradient (well MW211) of the AGSP, as presented on Table 3, are summarized below.

Position	Concentration ($\mu g/L$)						
	Arsenic	Cadmium	Copper	Lead	Manganese	Silver	Zinc
Upgradient	47.0 - 102	0.13 - 3.9	1.4 - 6.0	1 - 3.2	2 - 3.9	1.3 - 6	2 - 17
Downgradient	40.9 - 60.3	2.2 - 3.9	2.0 - 4.5	1.1 - 4.8	3.1 - 5.2	1.3 - 3.9	3 - 11.5

As shown, the upper bounds of the ranges for arsenic, copper, silver and zinc are larger for the upgradient samples relative to the downgradient samples. The upper bound of the cadmium range is the same for the upgradient and downgradient samples. The upper bounds of the lead and manganese ranges are only slightly higher in the downgradient samples relative to the upgradient samples.

2.4.4.4 <u>Direct Contact</u>

Direct contact with the AGSP is dependent on humans having physical access to the slag pile area. Such access by humans generally does not occur due to the presence of fencing and enforcement of access restrictions by security patrols. Even if direct contact with the AGSP occurred, the characteristics of the slag described above minimize potential exposures that might occur. Higher density

DRAFT

Table 3

GROUNDWATER CHEMISTRY DATA NEAR THE ANACONDA GRANULATED SLAG PILE

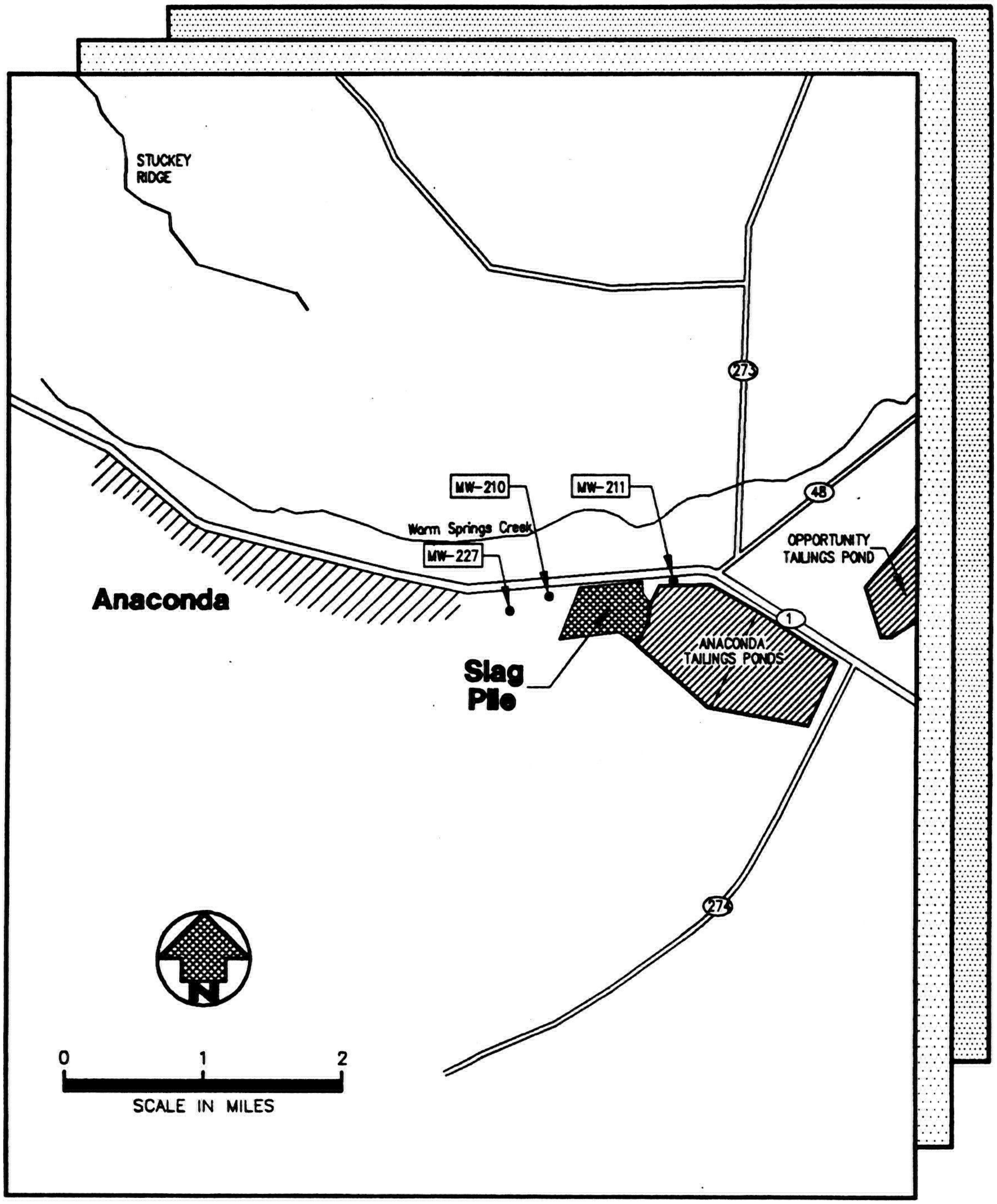
(All concentration data reflect dissolved forms and are in $\mu g/L$)

Well	Position[a]	Quarter/ Year	Arsenic	Cadmium	Copper	Lead	Manganese	Silver	Zinc
MW210	U	2/92	70.8	3.0	4.0	1	3.8	6	2
MW210	U	3/92	86.2	0.4	2.8	1.3	2	4	11.5
MW210	U	4/92	47.0	3.9	3.1	2.9	3.1	2.4	14
MW210	U	1/93	102	2.2	3.0	1.1	3.9	2.4	6.3
MW210	U	2/93	93.5	0.63	2	3.2	2.6	1.3	17
MW227	U	3/92	52.4	0.3	5.0	1.8	3	2.5	11.5
MW227	U	4/92	47.3	3.9	6.0	1.8	3.1	2.4	12
MW227	U	1/93	49.2	2.2	2.2	1.1	3.9	2.4	10.0
MW227	U	2/93	49.3	0.13	1.4	1.3	2.6	1.3	6
MW211	D	2/92	40.9	3.0	2.0	2.2	5	3.9	3
MW211	D	3/92	44.9	3.3	4.5	4.8	5.2	2.5	11.5
MW211	D	4/92	41.0	3.9	3.1	3.2	3.1	2.4	5.7
MW211	D	1/93	60.3	2.2	2.2	1.1	3.9	2.4	6.3
MW211	D	2/93	50.3	NA	3	2.4	5	1.3	7

[a] Position relative to the AGSP; U indicates upgradient of AGSP, D indicates downgradient of AGSP.

Source: Robert Galyen, personal communication, August 1, 1994.

8/94 D:\2350\2350-1.DWG



LEGEND

MW-210

APPROXIMATE MONITORING WELL LOCATION

LOCATION OF SELECTED MONITORING WELLS

PROJECT: 2350	DATE: AUGUST, 1994
REV:	BY: MEG | CHECKED:

Figure 2

and large particle size minimize the potential for atmospheric suspension and inhalation after mechanical disturbance. These characteristics also minimize the potential for adherence of slag particles to skin with subsequent ingestion.

Data from a study of individuals exposed to slag from a smelter located in Tacoma, Washington provide direct evidence of the limited potential for contact with slag to result in increased metals exposures (Allen et al., 1988). For most of its operating lifetime (between 1912 and 1986), this facility served as a copper smelter specializing in high-arsenic ores (EPA, 1992). Between 1890 and 1912, the facility had operated as a lead smelter. During a study conducted in 1987, human exposures to arsenic from slag were examined in young children (between the ages of 2 and 7 years) from 12 households where slag had been used around the home in driveways and walkways or as ornamental rocks. Exposure levels were assessed by analyzing arsenic concentrations in urine samples from these children and from 24 children from a control population with no slag exposures. Urinary arsenic concentrations in the children with slag exposures [i.e., a mean value of 7.11 nanograms per milliliter (ng/ml) and a range of <1.8 - 18.2 ng/ml] were essentially the same as those reported in the control children (i.e., a mean value of 7.41 ng/ml and a range of <1.8 - 22.8 ng/ml). These concentrations represent the sum of the inorganic, nonmethyl, and dimethyl arsenic concentrations identified in the urine samples. The results of the Tacoma study provide strong evidence that even direct contact with primary copper smelter slag, such as that comprising the AGSP, is unlikely to result in significant exposures to arsenic and lead contained in the slag.

DRAFT

3.0 SUMMARY OF SITE RISKS

The available physical and chemical data strongly indicate that the AGSP poses no risk to human health and the environment and point to the no-action alternative as being appropriate. The lack of risk is demonstrated by the following points.

- The mobility of metals and metalloids present in the slag particles in the air and surface-water pathways is negligible as shown by extensive air and surface water data collection activities, the relatively large and uniform particle size of the slag granules, and the high density of the slag.

- Laboratory tests indicate that the slag does not exhibit toxicity characteristics and that the slag's leachability is extremely low. These tests were conducted using aggressive, acidic leaching solutions that provide very conservative test results relative to leaching, if any, that may occur under field conditions.

- The low leaching potential of the slag, even when exposed to acidic solutions, is consistent with the incorporation of the metals and metalloids in an inert, iron silicate matrix. This vitrified matrix provides a texture similar to that achieved by a treatment method that has been performed by EPA for treatment of soils containing hazardous substances and that has demonstrated effectiveness in limiting the environmental mobility of metals.

- Due to the very dry conditions in the Anaconda area (annual precipitation << annual evaporation) and the heat retention characteristics of the dark slag material, the majority of incident rain water and snowmelt evaporates from the AGSP. Waters that do not evaporate do not concentrate as runoff. These waters are absorbed by pore spaces within the slag pile to fill soil-moisture deficiencies and are not transmitted through the base of the pile.

- EPA has made the determination that primary copper smelter slag does not pose a present or potential hazard to human health or the environment by exempting such slag from RCRA regulation as a hazardous waste [40 CFR Section 261.4(b)(7)].

- Direct contact with slag is limited by restricted access to the AGSP.

- Even if direct contact with slag occurs, exposure to arsenic and lead in the slag is likely to be minimal because high density and large particle size will minimize potential atmospheric suspension and limit adherence of particles to skin.

DRAFT

4.0 REFERENCES

Allen, A.M., N. Harris, D. Pierce, L. Alfonso, 1988. Pierce County Slag Study: an Arsenic Exposure Evaluation. Tacoma-Pierce County Health Department, Tacoma, WA. Final Report., March 14

ARCO, 1992. Preliminary Site Characterization Information (PSCI) Report, Anaconda Smelter NPL Site, Old Works/East Anaconda Development Area. March.

EPA, 1992. Baseline Risk Assessment, Ruston/North Tacoma Operable Unit Commencement Bay Nearshore/Tideflats Superfund Site, Tacoma, WA. Prepared for U.S. EPA Region 10 by SAIC. January.

EPA, 1991. Guide to Developing Superfund No Action, Interim Action, and Contingency Remedy RODs. OSWER Publication 9355.3-02FS-3, April, 1991.

Konizeski, R.L., R.T. McMurtrey, and A. Brietkrietz, 1968. Geology and Groundwater Resources of the Deer Lodge Valley, Montana. U.S. Geological Survey Water Supply Paper 1862.

Life Systems, 1993. Baseline Risk Assessment for the Old Works/East Anaconda Development Area Operable Unit. U.S. EPA Work Assignment Number 02-8P18. Prepared for Fluor Daniel, Inc., Dallas, TX.

PTI, 1993. Anaconda Smelter NPL Site, Smelter Hill Operable Unit Remedial Investigation Report, Vol. 1. November.

Tetra Tech, 1987. Anaconda Smelter RI/FS Master Investigation, Draft RI Report. Tetra Tech, Inc., Bellevue, WA.

Tetra Tech, 1985. Anaconda Smelter RI/FS Draft Stage 1 Remedial Investigation Report, May, 1985. Tetra Tech, Inc., Bellevue, WA.

Tetra Tech, 1984. Anaconda Smelter RI/FS Final Field Operations Plan Focused Investigation II Granulated Slag Pile. Tetra Tech, Inc., Bellevue WA.